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ABSTRACT

Previous work by Grannis and Jackson suggested that teachers, learners, feedback sources, instructional sequencing, material format, or other variables may exercise control over the learning environment. It was suggested that the behavioral structure of a classroom can be described in terms of a knowledge dimension, a social dimension, and an authority structure dimension, and that congruence between these dimensions creates a learning environment that is effective in eliciting achievement. The current research investigated the relationship between congruence and learner involvement in the task, and between congurence and achievement at two different levels of mental processing. One hundred fourteen ninth grade algebra students were taught a unit on probability with semi-programed materials. In two classrooms, the instruction was teacer-paced, and the teacher provided the authority structure of the classroom. In the other two classrooms, the work was individualized and self-paced. Though different distributions of control elicited varying amounts of on-task behavior, in all four learning environments the time spent on task was greater than 85 percent of the total. In terms of achievement, a combination of highly structured learning materials and a highly directive teaching style created the most effective environment both for lower and higher mental processes. (BW)

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The Effect of Learning Environment On Overt Learner Involvement and On Relevant Achievement

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Abstract

The results of this study indicate that the relationship between variables of control in the learning environment, as identified by Grannis and Jackson (1973) and either on-task behavior or relevant achievement is dependent upon the specifics of the teaching-learning process. When the environments identified as Congruent by Grannis and Jackson are compared with those identified as Congruent in this research, it becomes apparent that different combinations or distributions of control within the learning environment elicit the criterion variable depending upon learner age or subject area. Thus, what is needed is empirical support for the notion that environmental congruence as a theory cannot specify variable positions that generalize. The theory should only identify the quality of inter-relationships among the control variables within the learning environment.

A comprehensive examination of educational environment and a thorough investigation of their effect on relevant outcomes have potential for describing how, when, why and what type of school learning takes place. However, this potential can be realized only if certain characteristics of the learning environment can be identified and only if these characteristics predict desired learner behaviors.

In the past it has been recognized that there are elements of the learning environments which, to some extent, influence the amount and type of learning that occurs. Grannis (1971) and others (e.g., Anderson, 1939; Flanders, 1961) suggest that these influential elements within the learning environment may be conceptualized as controls operating over variable characteristics. This interpretation of control has resulted in a wide variety of research which generally questioned the effects of teacher behavior as a source of control on achievement outcomes.

Grannis and Jackson (1973) suggest that teachers, teachers and learners in combination, or learners alone make specific decisions about variable elements within the learning environment: teachers, teachers and learners in combination, and learners alone should be considered as having potential control within the classroom. However, other elements of the learning environment also exert control. These other elements include feedback sources, acceptable

conduct patterns, instructional sequencing, material format and so forth. Thus, Grannis and Jackson (1973) suggest a methodological framework which examines the effect of various controls in combination on learner achievement rather than on the effect of one source of control at a time. In short, one must identify patterns of control and examine the effects of differential patterns of control on relevant outcomes.

In order to address this need, Grannis and Jackson (1973) adopted a research methodology which enabled them to identify sources of control in the learning environment and to examine the effect of complex distributions of control variables on overt learner involvement in an educational task. Grannis and Jackson were operating under the assumption derived from previous theoretical and empirical work (e.g., Grannis, 1971; Anderson, 1939) that certain distributions of control variables were more effective in terms of designated outcomes than were other distributions.

Grannis (1971) suggests that the behavioral structure of the classroom can be described in terms of a knowledge dimension and a social dimension. Each of these dimensions represents a continuum along which the source of control over respective activities varies from teacher-controlled to child-controlled or from teacher-centered to child-centered (see Figure 1).

Insert Figure 1 About Here

Positions along each continuum are described as follows:

> The knowledge order is conceptualized as varying along a continuum from traditionally prescribed and proscribed through rationally prescribed to constructed. "Traditional" presumably speaks for itself. "Rationally prescribed" refers, epistemologically, to a conception of knowledge as given in reality, discovered by observation and reasoning, and tending toward the same form for all who submit objectively to observation and reasoning. Knowledge as "constructed" means knowledge as an invention of man that must conform to regularities in reality, or in nature, but that can take different forms in accordance with different judgments made in some respects for every individual, that though it must be consistent with reality, it can transcend the possibilities actualized in reality, and that it must be reconstructed in some sense by every individual who would master knowledge. The social order is conceptualized as varying along with the same dimension, from traditional through rationally prescribed to constructed . . . "traditional" again speaks for itself. "Rationally prescribed" corresponds to the viewpoint of the Enlightenment

> . . . "Constructed" refers best to our contemporary awareness of the possibility of inventing new social forms that go beyond the seeming dictates of nature (Grannis, 1971, pp. 7-8).

The bisection of the Knowledge Order and the Social Order continua is represented as a third continuum. This third continuum represents the authority structure of the learning environment. Thus, in Figure 1, as one moves diagonally across the Knowledge Order and Social Order matrix from the complementary Traditional Knowledge--Traditional Social quadrant to the complementary Constructed Knowledge--Constructed Social quadrant, one moves from environments which Grannis refers to as "dominative" to those which he calls "integrative" (after Anderson, 1939). By describing the Knowledge Order and Social Order characteristics of a given learning environment, one is able to identify a region along and about the dominative-integrative diagonal wherein that learning environment lies.

Once the authority structure of a learning environment has been identified, the issue of effectiveness can be addressed. Grannis suggests that effective learning environments are those which fall on the dominative-integrative continuum. An effective learning environment will tend to have complementary Knowledge Order and Social Order positions (Grannis, 1971, p. 11). The Knowledge Order and Social Order positions of ineffective learning environments will tend not to be complementary (Grannis and Jackson, 1973, p. 25).

Grannis used "Congruent" to label these learning environments in which the Knowledge Order and the Social Order are complementary. He labeled learning environments with uncomplementary Knowledge Order and Social Order positions "Incongruent."

Based on this conception of learning environments, one can identify combinations of social and knowledge characteristics that define an effective learning environment. For example, an environment with a Traditionally Prescribed Social Order and a Traditionally Prescribed Knowledge Order would be identified as an effective, i.e., Congruent, learning environment. However, Congruent learning environments may differ in the types of learning that they promote.

Theoretically, the learning environment's position on the dominative-integrative diagonal will determine the type of learning elicited. Specifically, Grannis suggests that skill learning is fostered by Congruent environments located toward the dominative end of the diagonal. In contrast, he suggests that application learning is fostered by Congruent environments located toward the integrative end of the diagonal (Grannis, 1971, pp. 13-14).

To summarize, Grannis (1971) had developed a theory of classroom effectiveness based on observed differences in teacher and/or learner control, with respect to the Knowledge and Social Orders. He hypothesized that the products of effectiveness on the dominative-integrative continuum would change as one moved along it. For example, Grannis suggested that, in a highly directive learning environment, i.e., a Traditional Knowledge-Traditional Social

environment, simple task learning would be maximized.

In order to provide empirical evidence that Congruent learning environments were, indeed, more "effective" than were Incongruent learning environments, Grannis and Jackson (1973) examined a variety of educational models associated with Project Follow Through. They anticipated being able to clarify their interest in the effects of different distributions of control within the learning environment through the observation of children's overt involvement in educational tasks among four different educational models. This study demonstrated that different distributions of control were associated with varying amounts of on-task behavior. Further, effective learning environments, in terms of overt learner involvement in an educational task, evidenced Congruent or complementary patterns of the four designated control variables.

However, Grannis and Jackson (1973) did not demonstrate that Congruent learning environments were equally as effective in eliciting achievement outcomes as they were in eliciting high levels of involvement or on-task behavior. Neither did they examine the effect of <u>different</u> types of Congruent learning environments on <u>different</u> types of achievement outcomes.

Thus, the purpose of this research was to address some of the questions left unanswered by the Grannis and Jackson (1973) study. Specifically, this research addressed the following questions:

1. What is the effect of the learning environment on learner involvement in the educational task?

2. What is the effect of the learning environment on relevant achievement?

For the purposes of this research, learner involvement was defined in terms of overt Time-on-Task (TOT) following the work of Anderson (1973). The achievement measures were defined in terms of probability knowledge (Lower Mental Process--LMP--behavior) and probability application (Higher Mental Process--HMP--behavior) following Levin (1975).

Research Procedures

This study took place during the first three weeks of the 1975-1976 school year. During this time the participating learners were exposed, in varying environmental conditions, to three semi-programmed units presenting four rules in introductory probability.

Pre-testing on general mathematics ability (MEDT) and on probability measures (LMP and HMP) occurred during the first three days of the study. Only those students who participated in all pre-testing activities were included as subjects in this study, although all students had the benefit of the materials during the study.

While the pre-tests were being administered, four observers were trained to use the overt measure of Time-on-Task (TOT) (following Anderson, 1973). The teachers were also trained for appropriate teaching behavior during the pre-testing.

After the pre-testing had been completed, the students in each learning environment received the appropriate set of learning materials. In learning environments I and II, the learners worked

through the materials at their own rate. In learning environments III and IV, the learners worked as a group at a pace set by the teacher.

The post-tests were administered to each learner upon completion of the learning materials.

Sample

The students participating in this study included 114 lower, middle and upper class white ninth grade algebra students. Of these 114, fifty were male and sixty-four were female. These students were all classified as middle track mathematics students and were assigned to participate in this study by virtue of their decision to enroll in algebra and their resulting assignment to the four classes used in this research study.

Teachers

The two male teachers who participated in this study were both experienced. Both had taught ninth grade algebra prior to this study although neither had used the materials adapted for this research.

Research Design

Reviewing Grannis (1971), it is clear that it is necessary to take into account three dimensions in order to present a comprehensive description of a given learning environment. These three dimensions are: (1) Knowledge Order; (2) Social Order; and (3) Authority, i.e., the dominative-integrative diagonal. One can describe the Knowledge Order dimension of a learning environment as varying from Traditional

to Constructed. Similarly, one can describe the Social Order dimension of the learning environment as varying from Traditional to Constructed. In addition, one can describe the intersection of these dimensions as varying from a region of dominative behaviors to a region of integrative behaviors.

In order to address the research questions stated earlier, an experimental design was selected. Four prototype learning environments were designed to represent two qualitatively distinct Congruent learning environments and their corresponding Incongruent learning environments (following Granis and Jackson, 1973). However, due to difficulties in implementing the designed learning environments, the four environments studied represented one Incongruent learning environment and three Congruent learning environments. These four learning environments included one Child Control II Congruent learning environment, one Child Control II Incongruent learning environment, and two different Teacher Control Congruent learning environments.

The particular internal composition of each of these four learning environments was, to some extent, predetermined. Two environments (Congruent-Dominative and Incongruent-Dominative) included directive teaching behavior. The remaining two environments (Congruent-Integrative and Incongruent-Integrative) included non-directive teaching behavior. The other variable characteristics of each environment specified for this research were then chosen from a variety of possibilities somewhat restricted by the initial

commitment to specific teaching behaviors.

According to Grannis and Jackson (1973), the description of the teacher behavior determines whether the environment is theoretically under the control of the teacher or the learner or under some joint control. Grannis and Jackson used a variable labeled "Pacing" to describe teaching behavior (see the section of this chapter on "Operational Definitions"). If the Pacing variable is coded "High", the teacher is considered to be in control of the learning environment. If the Pacing variable is coded "Medium," there is considered to be joint control. And if the Pacing variable is coded "Low," the learner is considered to be in control. Thus, the notion of congruence is then specifically understood to refer to whether the positions of the other control variables, i.e., Material Responsiveness, Child-Child Interaction, and Task Options, are complementary to the Pacing variable.

An environment would be considered Congruent when one of the Congruent conditions stated in Table 1 obtains. In contrast, the three Incongruent conditions stated in Table 1 were designed to match the three Congruent conditions.

Insert Table 1 About Here

The selection of specific Congruent and Incongruent Teacher Control and Child Control II learning environments studied in this research was influenced by a desire to create realistic learning environments. The four conditions in Table 2 were identified as

meeting this requirement.

Insert Table 2 About Here

These conditions represent an example of Congruence and Incongruence at both the dominative and the integrative end of the dominative-integrative diagonal. One concept of interest in this study was the effect of different types of Congruent learning environments on lower mental process behavior (LMP) and on higher mental process behavior (HMP). For this reason, two very different types of Congruent learning environments and their paired Incongruent conditions were selected to be studied.

The justification for systematically varying only two variables in the transformation from Congruent to Incongruent condition in both the Child Control II and in the Teacher Control environments derives from the work of Grannis and Jackson (1973). They found that environments which had only one variable in a complementary position to the Pacing variable, i.e., a two-variable Congruent condition, produced a significantly smaller amount of on-task behavior than did a completely Congruent environment. This significant difference was not found in environments which had only one variable out-of-line with the Pacing variable, i.e., a three-variable Congruent condition. The selection of the specific variables to be placed out-of-line with the Pacing variable could only be guided by a desire to create realistic classroom conditions since Grannis and Jackson did not discriminate between "types" of Incongruent

environments in terms of which of the three variables, excluding the Pacing variable defined the Incongruent condition. In examining the relationship between environment and learner involvement, it is important to determine whether the learning environments as implemented were equivalent to the learning environments as designed. The possible discrepancy between environment design and environment implementation referred to above presents a serious problem in interpreting the results of this study. Therefore, it is necessary to examine the relationship between variable operationalization and variable implementation within each learning environment. The question of what effect the learning environment has on measures of learner involvement and on measures of cognitive achievement outcomes can then be resolved in terms of the environment as it was implemented.

Table 3 presents the learning environments as designed and as implemented. In addition, it indicates the location of a new variable, "Teacher Responsiveness."

Insert Table 3 About Here

Although "Low Material Responsiveness" as defined by Grannis and Jackson (1973) and as defined in this study was implemented in condition III, another source of feedback was clearly available to the learners. This new source of feedback is labeled "High Teacher Responsiveness." Conceptually, the position of this new variable

observed in condition III, i.e., "High Teacher Responsiveness," is complementary to High Pacing. Therefore, condition III can be defined as a four-variable Congruent learning environment.

Similarly, this new variable, "Teacher Responsiveness", is potentially available in condition IV. However, the teacher did not include discussions about the test responses in the lecture behavior. The absence of this discussion indicates that it is appropriate to identify "Low Teacher Responsiveness" in condition IV. The absence of teacher feedback with respect to test behavior suggests that there is less control over the learning in condition IV than in condition III.

Although the nature of the learning environments' implementation prevents the examination of the effect of Congruence at the dominative end of the authority diagonal possible given the nature of the learning environments as designed, the general question about the effect of Congruence can still be answered. The other research questions remain basically unaffected. Thus, the following discussion of the experimental design and the statement of the research hypotheses are presented in terms of the learning environments as implemented rather than as designed.

Experimental Design

In order to compare the effects of the four learning environments specified in the previous section, an experimental design was selected. The Independent Variable of interest in this study was learning environment. However, since no empirical evidence was available on

the possible interaction between sex and learning environment, sex was also treated as an Independent Variable. Diagramatically the design is as shown in Figure 2.

Insert Figure 2 About Here

This specific conceptual model identifies each component of the general model as discussed previously. The relations among the parts of the model lead to the following research questions:

1. What is the effect of the learning environment on the composite Time-on-Task (TOT) variable?
2. What is the effect of the learning environment on Probability Knowledge (LMP) and Probability Application (HMP)?

Research Hypotheses

The following research hypotheses derive from the two general research questions stated above:

H1: A significantly greater amount of on-task (TOT) behavior will result from the three Congruent learning environments than will result from the Incongruent learning environment.

H2: A significantly higher mean score on the Lower Mental Process (LMP) measure will result from either of the Teacher Control Congruent learning environments than will result from either of the

Child Control II learning environments, either Congruent or Incongruent.

H3: A significantly higher mean score on the Higher Mental Process (HMP) measure will result from the Child Control II Congruent learning environment than will result from either of the Teacher Control Congruent learning environments.

H4: No significant differents on either the Lower Mental Process (LMP) measure or the Higher Mental Process (HMP) measure will result among the four learning environments with Time-on-Task (TOT) held constant.

The first hypothesis was tested using a two-way (Treatment of Sex) analysis of covariance. The three pre-test measures (NEDT, LMP-Pre, and HMP-Pre) were used as covariates. The second and third hypotheses were tested simultaneously using a two-way (Treatment by Sex) multivariate analysis of covariance. The covariates included the three pre-test measures (NEDT, LMP-Pre, and HMP-Pre). The fourth hypothesis was tested using a two-way (Treatment by Sex) analysis of covariance with the three pre-test measures used as covariates and with Time-on-Task (TOT) also used as a covariate.

Results

Prior to presenting a summary of the results of this study, it is important to emphasize two factors. First, the learning environments as implemented deviated from the learning environments as

designed. Second, the nature of the semi-programmed learning materials appears to have been uniformly powerful so as to reduce the possible interaction among control variables theoretically in uncomplementary positions with respect to the Pacing variable. Thus, although this research expands the Grannis theory of environmental congruence in many respects, it would be inappropriate to interpret the results of this study as disconfirming the results of the Grannis and Jackson (1973) report. In addition, it should be kept in mind that the subject area studies in this research and the developmental characteristics of the participating learners differed markedly from the learning materials and the participating learners studied in the Grannis and Jackson (1973) investigation.

As reported in Table 4, the average amount of observed overt

Insert Table 4 About Here

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learner involvement was high. An average of greater than eighty-five percent was reported for on-task behavior in each learning environment. Thus, the data do not support the conclusion offered by Grannis and Jackson (1973) that more on-task behavior is fostered in Congruent learning environments. The effect of the semi-programmed learning materials appear to have been relatively uniform and relatively powerful.

As reported in Table 5, the correlations between TOT and either Lower Mental Process (LMP) achievement or Higher Mental Process (HMP)

achievement are non-significant. These correlation coefficient values appear to contradict extensive prior research on the relationship between overt measures of learner involvement and relevant achievement (e.g., Bloom, 1968; Block, 1971; Anderson, 1973). However, this can be explained by the low variability among the four learning environments with respect to TOT.

Insert Table 5 About Here

Despite the relatively high and relatively uniform level of TOT across learning environments, one would expect different types of non-verbal on-task behavior manifested in the Self-Paced learning environment than in the Teacher-Paced learning environment. For example, if one of the advantages of programmed materials is that the learner can work at his/her own pace, one would expect that more "W" type of overt learner involvement would be observed, i.e., behaviors of the student which indicate to the observer that the student is actively working with the materials. Similarly, since learning environments III and IV are lecture situations the learners might not respond to the semi-programmed materials by writing answers in the workbook. And, since the learners had been provided with detailed materials upon which the lecture was based and therefore had less need to take extensive notes, one would expect that more "A" type of overt learner involvement would be observed, i.e., behaviors of the student which indicate to the observer that the student is physically attending to the task.

However, as reported in Table 6, these anticipated differences in types of non-verbal TOT among the four learning environments are not observed and the variability of either "W" or "A" among the four learning environments is narrow.

Insert Table 6 About Here

In examining the correlation coefficients (reported in Table 7) between "W" and "A" and both LMP and HMP, one finds that none of the observed relationships reach statistical significance. Thus, for the purposes of this study, these two specific components of the TOT composite variable do not provide insight into identifying differences among the four learning environments in terms of learner overt behaviors.

Insert Table 7 About Here

Lower Mental Process (LMP) and Higher Mental Process (HMP) Achievement

As reported in Table 8, the raw means by learning environment for the LMP and the HMP outcome measures indicate that the learners did

Insert Table 8 About Here

better on Lower Mental Process (LMP) tasks than on Higher Mental Process (HMP) tasks. As reported in Table 9, of a total possible score of twenty-nine on the LMP measure, the average performance among

Insert Table 9 About Here

all learners participating in this study is 19.33. This average is compatible with the average of the non-mastery and mastery groups' performance on this same measure reported by Levin (1975).

The average performance on the Higher Mental Process (HMP) measure reported by Levin (1975) is 11.66. Thus, the average performance for the learners participating in this study is equivalent to the average for the mastery and non-mastery groups participating in Levin's study.

The Effect of Learning Environments on Time-on-Task (TOT)

The purpose of the first hypothesis was to examine the effect of learning environment on learner overt involvement in an educational task, i.e., TOT. The related hypothesis was formulated as follows:

H1: No significant differences in on-task (TOT) behavior will result from any of the three types of learning environments.

As reported in Table 10, a significant differences ($F = 4.6504$, $p < .0044$) exists among the learning environments with TOT as the criterion variable. Thus, H1 is rejected.

Insert Table 10 About Here

In order to determine the direction of the significant difference, the adjusted means reported in Table 11 were graphed

Insert Table 11 About Here

(see Figure 3). About each mean is graphed a confidence region of

Insert Figure 3 About Here

two standard errors. By examining the overlaps of these regions for the four environments, it appears that, at the .05 level, significant differences exist between the Self-Paced Material-Responsive II learning environment and either of the Teacher-Paced learning environments.

Due to the theoretical equivalency of the two self-paced learning environments, it is appropriate to examine the average on-task behavior of these two environments combined as compared to either of the teacher-paced learning environments. Rather than use the conservative method of the mean plus or minus two standard errors used in Figure 3, these comparisons were examined using Scheffe's method of multiple comparisons (Glass and Stanley, 1971, pp. 381-399).

As reported in Table 11, the difference between the combined average TOT level of the Self-Paced learning environments as compared to the Teacher-Paced Teacher-Responsive learning environment is significant ($p < .05$). However, the contrast of the Self-Paced average with the Teacher-Paced Material-Responsive is not significant ($p < .05$).

Referring to Table 12, one can suggest from these results that the presence of Teacher-Responsive behaviors significantly reduced

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Insert Table 12 About Here

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the level of on-task behavior. Attempts to involve students in discussion, the presentation of novel examples and other characteristics of the Teacher-Responsive variable may have distracted the learners from overt involvement with the learning materials. However, since the average of the two Teacher-Paced environments is significantly less than the Self-Paced Material-Responsive I learning environment, one can suggest that teacher lecture behavior in general, with and without the responsive teacher behavior, distracted the learners from the materials, from the lecture itself, and so on.

Other elements of the environments may also account for these differences. For example, in a lecture situation, the learners are likely to hold their heads in an upright position to facilitate eye-contact with the teacher. In this position, the students have the potential to be easily distracted by activities outside the classroom viewed through windows and so forth. In contrast, those students in the self-paced learning environment are likely to hold their heads down in order to facilitate eye-contact with the written materials.

Whatever the source of this significant difference, even the lowest average TOT behavior exceeds 85%. The question of what level of TOT is necessary for achievement is beyond the scope of this research.

The fact that the highest adjusted mean TOT level in either of the Teacher-Paced learning environments is in the Teacher-Paced Material-Responsive environment supports the conclusion that the materials become less efficient in eliciting overt learner involvement when distracting or competing components are present within the environment.

One can conclude that the learning materials elicit the most on-task behavior when no other environment control variables compete with respect to providing alternative sources of feedback to the learners. It is also clear that the learning materials are sufficiently powerful or attractive to the learners that, even when competing control variables are present, an average of no less than eighty percent was observed.

This data suggests that if TOT is the criterion of effectiveness, an environment which contains semi-programmed instructional materials with a minimum of environmental "distractors" is effective. One would expect increasingly high levels of TOT as distractors were removed from the environment. Thus, in the type of environment for which programmed materials were designed, i.e., the highly individualized learning situation, TOT should reach its optimum. Whether this indeed happens and whether optimum TOT and optimum achievement occur simultaneously are questions for future research.

An alternative explanation for the uniformly high levels of TOT departs from the nature of the learning materials. It focuses on the nature of the training and educational socialization of the

subjects studied in this research. Bernstein (1968) suggests that middle-class students readily become socialized to a highly structured learning environment. They adapt quickly to self-paced learning materials and may also become resistant to distractions. Although the learners participating in this research are not all middle class, it is likely that the majority of them are. Thus, this socialization hypothesis is plausible.

The Effect of Learning Environments on Lower Mental Process (LMP) and on Higher Mental Processes (HMP)

The second research question focuses on the effects of the learning environment on a different, and more typical, criterion of "effectiveness": achievement. Grannis (1971), among others, has suggested that different types of learning environments elicit qualitatively different types of achievement outcomes. In order to examine this relationship, the following hypotheses were formulated:

H2: A significantly higher mean score on the Lower Mental Process (LMP) measure will result from the Teacher-Paced Material-Responsive learning environment than from the other learning environments.

H3: A significantly higher mean score on the Higher Mental Process (HMP) measure will result from either of the Self-Paced learning environments or from the Teacher-Paced Teacher-Responsive learning environment than will result from the

Teacher-Paced Material-Responsive learning environment.

The LMP raw means, reported in Table 13, indicate that more probability knowledge was produced by the Teacher-Paced learning

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Insert Table 13 About Here

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environments than was produced by either of the Self-Paced learning environments. Similarly, the HMP raw means, also reported in Table 13, indicate that more probability application behavior was also produced by the Teacher-Paced learning environments than was produced by either of the Self-Paced learning environments.

However, in order to test H2 and H3, it is necessary to control for differences in pre-test performance levels among the learners as in the test of H1. It is also preferable to test the differences in LMP and HMP simultaneously (Bock, 1975). Thus, a multivariate analysis of covariance was used to test H2 and H3. The covariates included the three pre-test measures (NEDT, LMP-Pre, and HMP-Pre).

As reported in Table 14, there is a significant multivariate F (3.2236) for treatment, i.e., environment. The Step Down F is

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Insert Table 14 About Here

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significant for both LMP and HMP. This indicates that each is significant independent of the other outcome variable.

In order to determine which learning environments were significantly different from each other with respect to either LMP or HMP, the adjusted means and two standard errors were graphed for each learning environment (See Figures 4 and 5).

Insert Figure 4 About Here

Insert Figure 5 About Here

As indicated in Figure 4, the Teacher-Paced Teacher-Responsive learning environment elicited a significantly higher mean achievement level than did any of the other three learning environments with respect to LMP achievement. The other three learning environments (Self-Paced Material-Responsive I and II and Teacher-Paced Material-Responsive) were not significantly different from each other with respect to LMP. Thus, with LMP as the criterion variable, the Teacher-Paced Teacher-Responsive learning environment is the most effective.

In order to examine the differences with respect to LMP between the combined and conceptually equivalent environments and the Teacher-Paced Material-Responsive learning environment, Scheffe's method of multiple comparisons was used. As indicated in Table 15, no significant differences were detected.[1]

Insert Table 15 About Here

Based on the significant difference between the Teacher-Paced Teacher-Responsive learning environment and the other three learning environments, H2 is accepted with a qualification. This qualification is necessary since both Teacher Control learning environments were not equally effective in terms of eliciting LMP achievement. The most effective learning environment in terms of LMP is the environment in which feedback on test behavior was included as part of the teaching behavior.

The identification of the Teacher-Paced Teacher-Responsive learning environment as the most effective in terms of Lower Mental Process behavior supports the literature cited earlier (e.g., Horrocks, 1964; Lewin, Lippit and White, 1939) which stated that simple tasks are most efficiently learned in an authoritarian or highly directive learning environment. However, if teaching behavior were the sole determinant in the production of LMP behaviors, both learning environments III and IV would have elicited similar levels of Lower Mental Process achievement. As this was not the case, one may conclude that the critical difference in this study was the position of the teacher behavior on the newly defined "Teacher Responsiveness" variable, i.e., High or Low. In fact, this new variable appears to compensate for the absence of "High Material Responsiveness" in condition III.

Referring to Figure 5, one notices that there are no statistically significant differences in LMP achievement among conditions I, II, and IV (this is verified using Scheffe's multiple comparison

procedure reported in Table 15). Since condition III was the only learning environment which included "High Teacher Responsiveness" as a control variable, it can be argued that regardless of "High Material Responsiveness," "High Child-Child Interaction," or "Low Pacing," the mechanism of the learning environment which fosters achievement in probability knowledge (LMP) is the structured discussion of test problems led by the teacher.

The most dramatic contrast among the four learning environments examined in this study is between the Self-Paced Material-Responsive II and the Teacher-Paced Material-Responsive learning environments. Between these two environments, the teacher behavior is the only variable element. Thus, these two environments provide a test of the effect of dichotomous teacher behaviors on on-task behavior. And, as indicated previously, the non-directive Low Pacing teacher behavior is least effective.

With respect to the Higher Mental Process (HMP) measure, the Teacher-Paced learning environments (III and IV) elicited higher adjusted mean achievement levels than did the Self-Paced learning environments (I and II).[2] These results contradict the theory supported by Lewin, Lippit and White (1939) and others (e.g., Adams, 1954) that higher level cognitive behaviors are manifested in child-centered or non-directive learning environments. This suggests that the notion that authoritarian or directive teacher behaviors are less effective in terms of eliciting complex cognitive behavior may not refer to low level complex behaviors such as application.

It may also indicate that the reduced effectiveness of directive teacher behaviors cited in the research (e.g., Anderson, 1959) does not hold for all content areas. It may be the nature of introductory probability as a content area that the most effective way to learn it is to have it presented in a highly structured way. Since no statistically significant differences occur between the two Teacher-Paced learning environments, it does not appear that "High Teacher Responsiveness" contributes in a meaningful way to HMP achievement.

In order to examine the differences with respect to HMP between the combined Self-Paced learning environments and either of the Teacher-Paced environments, Scheffe's method of multiple comparisons was used. No significant differences are reported for the contrast of the Self-Paced combination with the Teacher-Paced Material-Responsive learning environment. Significant differences are reported in the contrast with the Teacher-Paced Teacher-Responsive learning environment.

Based on the interpretation of Figure 5 and of Table 15, H3 is accepted with a qualification. The Self-Paced environments did not effect achievement as predicted (following Lewin, Lippit and White, 1939; Horrocks, 1964; and others). The Teacher-Paced Teacher-Responsive learning environment did, however, elicit the highest levels of HMP achievement. Thus, this environment is effective with respect to <u>both</u> LMP and HMP achievement.

Relationship Between Time-on-Task (TOT) and Achievement (Both LMP and HMP)

As indicated in the general model for this research (see Figure 2), the effect of the learning environment on achievement outcomes is theoretically mediated by the amount of overt learner involvement in the educational task. If this is a valid assumption, any mean differences in achievement among the four learning environments with respect to achievement outcomes should be reduced or removed by controlling for differences in Time-on-Task (TOT) behavior.

The following hypothesis is appropriate to test this relationship between learner involvement and probability achievement.

H4: No significant differences on either the Lower Mental Process (LMP) measure or on the Higher Mental Process (HMP) measure will result among the four learning environments with Time-on-Task (TOT) held constant.

In order to test this hypothesis, a multivariate analysis of covariance was performed. The covariates included the three pre-test measures (NEDT, LMP-Pre, and HMP-Pre) and the composite variable Time-on-Task (TOT). As indicated in Table 16, the signifi-

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Insert Table 16 About Here

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cant differences among the four learning environments reported with respect to LMP and to HMP in the test of H2 and H3 remain after

adjustments were made for differences in TOT. Thus, H4 is rejected.

The fact that controlling for differences in TOT among the four learning environments does not remove or reduce the differences with respect to the achievement outcomes is not surprising given that the correlations reported between TOT and either LMP or HMP are not significant (see Table 9). Had the semi-programmed learning materials not been uniform in their ability to elicit high levels of overt learner involvement, or had the learners themselves been less well socialized to patterns of behavior acceptable in a mathematics class, the variance in TOT may not have been so constrained.

Summary

In attempting to examine the relationship between specific learning environments and learner involvement in an educational task (Time-on-Task) and achievement measures (Lower Mental Process and Higher Mental Process Behaviors), this research has produced some provocative findings. With respect to Time-on-Task (TOT), this study indicates that different distributions of control within the learning environment do elicit varying amounts of on-task behavior. However, the average amounts of on-task behaviors in all four learning environments is relatively high, i.e., greater than eighty-five per cent. Thus, it may be that all four learning environments are "effective" in terms of on-task behavior. The question to be asked deriving from this observation is: how much on-task behavior is enough?

If the criterion for effective learning environments is achievement instead of on-task behavior, the results of this study suggest that highly structured learning materials and a highly directive teaching style are compatible and therefore create an effective learning environment. And this effectiveness appears to hold whether one is discussing Lower Mental Process (LMP) behavior or Higher Mental Process (HMP) behavior. One can further speculate that given materials which include process-oriented practice, an environment which includes "High Teacher Responsiveness" may elicit the highest levels of both LMP and HMP achievement. However, it remains to be established whether the compatibility between High Material Responsiveness, High Pacing, and High Teacher Responsiveness is valid in other situations.

Thus, in response to the research questions stated at the beginning of this chapter:

1. What is the effect of the learning environment on learner involvement in an educational task?
2. What is the effect of the learning environment on achievement?

one can conclude the following. With respect to overt learner involvement in an educational task, the optimal envionrmental distributions of control variables for this particular learner group and for this particular subject area appears to be one in which the materials offer high feedback (High Material Responsiveness) and in which none of the other variables (Pacing, Task Options, or Child-

Child Interaction) provide any form of distraction to the learners.

With respect to achievement outcomes, the optimal environmental distribution of control variables for this particular learner group and for this particular subject area appears to be one in which the teacher behaves in a highly directive fashion which includes providing feedback specific to test performance, and one in which the materials also provide highly structured and immediate feedback.

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Footnotes

[1]This procedure was not used to examine the differences between the combined self-paced learning environments and the Teacher-Paced Teacher-Responsive learning environment since each self-paced environment was significantly different from that environment.

[2]The combined self-paced learning environments were not significantly different from the Teacher-Paced Material-Responsive learning environment (see Table 15).

Table 1

Congruent Conditions

Teacher Control	Child Control I	Child Control II
High Pacing	Medium Pacing	Low Pacing
No Task Options	Task Options	Task Options
None or Low Material Responsiveness	High Material Responsiveness	High Material Responsiveness
Low Child-Child Interaction	Medium Child-Child Interaction	High Child-Child Interaction

Incongruent Conditions

High Pacing	Medium Pacing	Low Pacing
Task Options*	No Task Options*	No Task Options*
None or Low Material Responsiveness	High Material Responsiveness	Low Material Responsiveness*
High Child-Child Interaction*	No Child-Child Interaction*	High Child-Child Interaction

*indicates those variables which are not in a complementary position to the Pacing variable and thus create an Incongruent learning environment.

Table 2

The Four Conditions Meeting the Requirement of

Realistic Learning Environments

	Congruent	Incongruent
Child Control II	Low Pacing	Low Pacing
	Task Options	No Task Options*
	High Material Responsiveness	High Material Responsiveness
	High Child-Child Interaction	Low Child-Child Interaction
Teacher Control	High Pacing	High Pacing
	No Task Options	Task Options*
	Low Material Responsiveness	High Material Responsiveness*
	Low Child-Child Interaction	Low Child-Child Interaction

*indicates those variables which are not in a complementary position to the Pacing variable and thus create an Incongruent learning environment.

Table 3

Control Variables for Each Learning Environment as Designed and as Implemented

Designed Label	Variables	Implemented Label	Implemented Variable
Child Control II	Low Pacing	Self-Paced Material-	Low Pacing
Congruent	Task Options [b]	Responsive	No Task Options
	High Material Responsiveness		High Material Responsiveness
	High Child-Child Interaction [b]		Slight Child-Child Interaction
Child Control II	Low Pacing	Self-Paced Material-	Low Pacing
Incongruent	No Task Options [a]	Responsive II	No Task Options
	High Material Responsiveness		High Material Responsiveness
	Low Child-Child Interaction [a]		Some Child-Child Interaction
Teacher Control	High Pacing	Teacher-Paced Teacher-	High Pacing
Congruent	No Task Options	Responsive	No Task Options
	Low Material Responsiveness		Low Material Responsiveness
	Low Child-Child Interaction [b]		High Teacher Responsiveness [c]
			Slight Child-Child Interaction

Table 3 Continued

Designed Label	Variables	Implemented Label	Implemented Variable
Teacher Control	High Pacing	Teacher-Paced Material-	High Pacing
Incongruent	Task Options [a] [b]	Responsive	No Task Options
	High Material Responsiveness		High Material Responsiveness
	Low Child-Child Interaction		No Teacher Responsiveness [c]
			Some Child-Child Interaction

[a] Incongruent variables

[b] Variables not implemented

[c] New variable

Table 4[a]

Means, Standard Deviations and Inclusive Ranges for Time-On-Task by Learning Environment

(N = 114)

	Learning Environment	Mean	Standard Deviation	Inclusive Range	Low Score	High Score
I.	Self-Paced Material Responsive I (N=26)	90.04	10.45	34	67	100
II.	Self-Paced Material Responsive II (N=29)	92.86	7.47	26	75	100
III.	Teacher-Paced Teacher-Responsive (N=31)	85.86	6.17	27	74	100
IV.	Teacher-Paced Material-Responsive (N=28)	86.70	6.96	27	72	98

Grand Mean = 88.80

Standard Deviation = 8.23

[a] This data is based on an overall average of 79.02 observations per student (See Appendix A). As these observations were made at random throughout the instructional period of the study, the behaviors reported are considered to be representative of all occurring behavior. The results reported in Table 7 support the statements made in Chapter III that the effect of the semi-programmed learning materials would be relatively uniform and relatively powerful.

Table 5

Correlational Matrix of Time-On-Task With Lower Mental Process (LMP) Behavior and Higher Mental Process (HMP) Behavior by Class

(N = 114)

Learning Environment	Lower Mental Process (LMP)	Higher Mental Process (HMP)
I. Self-Paced Material-Responsive I (N=26)	-.10	.06
II. Self-Paced Material-Responsive II(N-29)	.46*	.21
III. Teacher-Paced Teacher-Responsive (N=31)	.31	-.08
IV. Teacher-Paced Material-Responsive(N-28)	-.11	.33

*p <.05

Table 6

Means and Standard Deviations for "W" and "A"

by Learning Environment

(N = 114)

	Learning Environment	Variable	Mean	Standard Deviation
I.	Self-Paced Material-Responsive I	"W"	22.46	7.04
II.	Self-Paced Material-Responsive II	"W"	17.72	4.92
III.	Teacher-Paced Teacher-Responsive	"W"	19.00	5.04
IV.	Teacher-Paced Material-Responsive	"W"	21.07	6.94
I.	Self-Paced Material-Responsive I	"A"	66.17	12.78
II.	Self-Paced Material-Responsive II	"A"	67.60	7.00
III.	Teacher-Paced Teacher-Responsive	"A"	62.07	7.02
IV.	Teacher-Paced Material-Responsive	"A"	69.96	8.72

Grand Mean "W" = 19.97

Grand Mean "A" = 66.35

Standard Deviation "W" = 6.20

Standard Deviation "A" = 9.39

Table 7

Correlation Matrix Between "W" and "A" and Both Lower Mental Process (LMP) Achievement and Higher Mental Process (HMP) Achievement by Learning Environment (N = 114)

	Learning Environment	Variable	Lower Mental Process (LMP)	Higher Mental Process (HMP)
I.	Self-Paced Material-Responsive I	"A"	.24	-.05
II.	Self-Paced Material-Responsive II	"A"	.10	-.01
III.	Teacher-Paced Teacher-Responsive	"A"	.34*	-.13
IV.	Teacher-Paced Material-Responsive	"A"	-.09	.33
I.	Self-Paced Material-Responsive I	"W"	-.27	-.01
II.	Self-Paced Material-Responsive II	"W"	.29	.13
III.	Teacher-Paced Teacher-Responsive	"W"	.03	-.01
IV.	Teacher-Paced Material-Responsive	"W"	-.13	-.06

*$p < .05$

Table 8

Pre-Test and Post-Test Raw Means and

Standard Deviations by Class

Learning Environments	Variables	Raw Means	Standard Deviation
I	LMP-Pre[a]	2.38	1.93
	HMP-Pre[b]	1.00	1.12
	NEDT	17.96	5.16
	LMP-Post	18.50	5.16
	HMP-Post	10.54	6.14
II	LMP-Pre	2.89	1.73
	HMP-Pre	0.68	.71
	NEDT	15.75	6.63
	LMP-Post	19.00	5.22
	HMP-Post	10.86	4.27
III	LMP-Pre	2.46	1.74
	HMP-Pre	.50	.73
	NEDT	17.61	5.67
	LMP-Post	20.68	5.76
	HMP-Post	12.96	4.41

Table 8 Continued.

Learning Environments	Variables	Raw Means	Standard Deviation
IV	LMP-Pre	2.80	2.48
	HMP-Pre	1.16	1.12
	NEDT	14.80	4.46
	HMP-Post	19.16	4.68
	LMP-Post	12.28	4.42

[a] Indicates the probability measure of lower mental processes, i.e., Knowledge behaviors.

[b] Indicates the probability measure of higher mental processes, i.e., Application behaviors.

Table 9

Grand Mean and Standard Deviation For Lower Mental Process (LMP) and Higher Mental Process (HMP) Behavior (N = 114)

Variable	Mean	Standard Deviation
LMP	19.33	0.94
HMP	11.66	1.15

Table 10

Treatment Effect for Analysis of Covariance

For Time-On-Task (TOT)

(N = 114)

Variable	Hypothesis Mean Square	Univariate F	p less than
TOT	293.0346	4.6504	0.0044

D.F. = 3, 103

Table 11

Time-On-Task Raw Means, Standard Deviations, Adjusted Means, Standard Errors, and Confidence Intervals by Learning Environments

(N = 114)

	Learning Environment	Raw Mean	Standard Deviation	Adjusted Mean	Standard Error	Confidence Intervals
I.	Self-Paced Material-Responsive I (N = 26)	90.04	10.45	90.11	.74	88.52-91.59
II.	Self-Paced Material-Responsive II (N = 29)	92.86	7.47	92.63	.74	91.15-94.11
III.	Teacher-Paced Teacher-Responsive (N = 31)	85.04	6.17	85.43	.74	83.25-86.91
IV.	Teacher-Paced Material-Responsive (N = 28)	86.76	6.96	87.73	.74	86.25-89.21

Table 12

Scheffe's Method of Multiple Comparisons for

Time-On-Task (TOT)

Contrast	Estimate of Contrast ($\hat{\psi}$)	Estimate of Variance of Contrast ($\hat{\sigma}^2_{\psi}$)	df	$\hat{\psi}/\hat{\sigma}_{\psi}$
$\frac{u_1 + u_2}{2} - u_3$	6.01	3.15	2,84	3.39[a]
$\frac{u_1 + u_2}{2} - u_4$	3.71	3.15	2,84	2.09[b]

[a] significant at $p < .05$

[b] non-significant at $p < .05$

Table 13

Raw Means, Standard Deviations, Adjusted Means and Standard Errors for LMP and HMP by Learning Environment

(N = 114)

Learning Environment	Variable	Raw Mean	Standard Deviation	Adjusted Mean	Standard Error
Self-Paced Material Responsive I	LMP	18.50	5.14	17.66	.38
Self-Paced Material-Responsive II	LMP	19.00	5.22	18.94	.38
Teacher-Paced Teacher-Responsive	LMP	20.68	5.76	20.60	.38
Teacher-Paced Material-Responsive	LMP	19.16	4.70	18.78	.38
Self-Paced Material-Responsive I	HMP	10.54	6.14	10.20	.34
Self-Paced Material-Responsive II	HMP	10.86	4.27	10.88	.34
Teacher-Paced Teacher-Responsive	HMP	12.96	4.41	12.77	.34
Teacher-Paced Material-Responsive	HMP	12.28	4.42	12.14	.34

Table 14

The Effects of Learning Environments on Probability Knowledge (LMP) and Application (HMP) Behavior

(N = 114)

F-ratio for Multivariate Test of Equality of Mean Vectors = 3.2236

D.F. = 6, 204 p .0048

Variable	Hypothesis Mean Square	Univariate F	p	Step Down F	p
LMP	55.1147	3.3509	0.0220	3.3509	0.0220
HMP	54.5425	4.0782	0.0089	3.1290	0.0220

Table 15

Scheffe's Method for Multiple Comparisons for Lower Mental Process (LMP) and Higher Mental Process (HMP) Behaviors

Variable	Contrast	Estimate of Contrast $\hat{\psi}$	Estimate of Variance of Contrast $\hat{\sigma}_{\hat{\psi}}$	df	$\hat{\psi}/\hat{\sigma}_{\hat{\psi}}$
LMP	$u_1 - u_4$	-1.12	1.15	2,52	1.04[a]
LMP	$\frac{u_1 - u_2}{2} - u_3$	-2.26	.86	2,84	2.49[a]
HMP	$\frac{u_1 + u_2}{2} - u_4$	-1.58	.66	2,55	1.43[a]
HMP	$\frac{u_1 + u_2}{2} - u_3$	-1.57	.55	2,84	2.12[a]

[a] non-significant at $p < .05$

Table 16

The Effects of Learning Environments on Probability Knowledge (LMP) and on Probability Application (HMP) with Initial Cognitive Entry Behaviors and Time-On-Task (TOT) Held Constant

(N = 114)

F-ratio for Multivariate Test of Equality of Mean Vectors = 3.3236

D.F. = 6 and 202 p .0039

Variable	Hypothesis Mean Square	Univariate F	p	Step Down F	p
LMP	59.3006	3.6018	0.0161	3.6018	0.0161
HMP	54.9140	4.0728	0.0090	3.0822	0.0308

Figure Captions

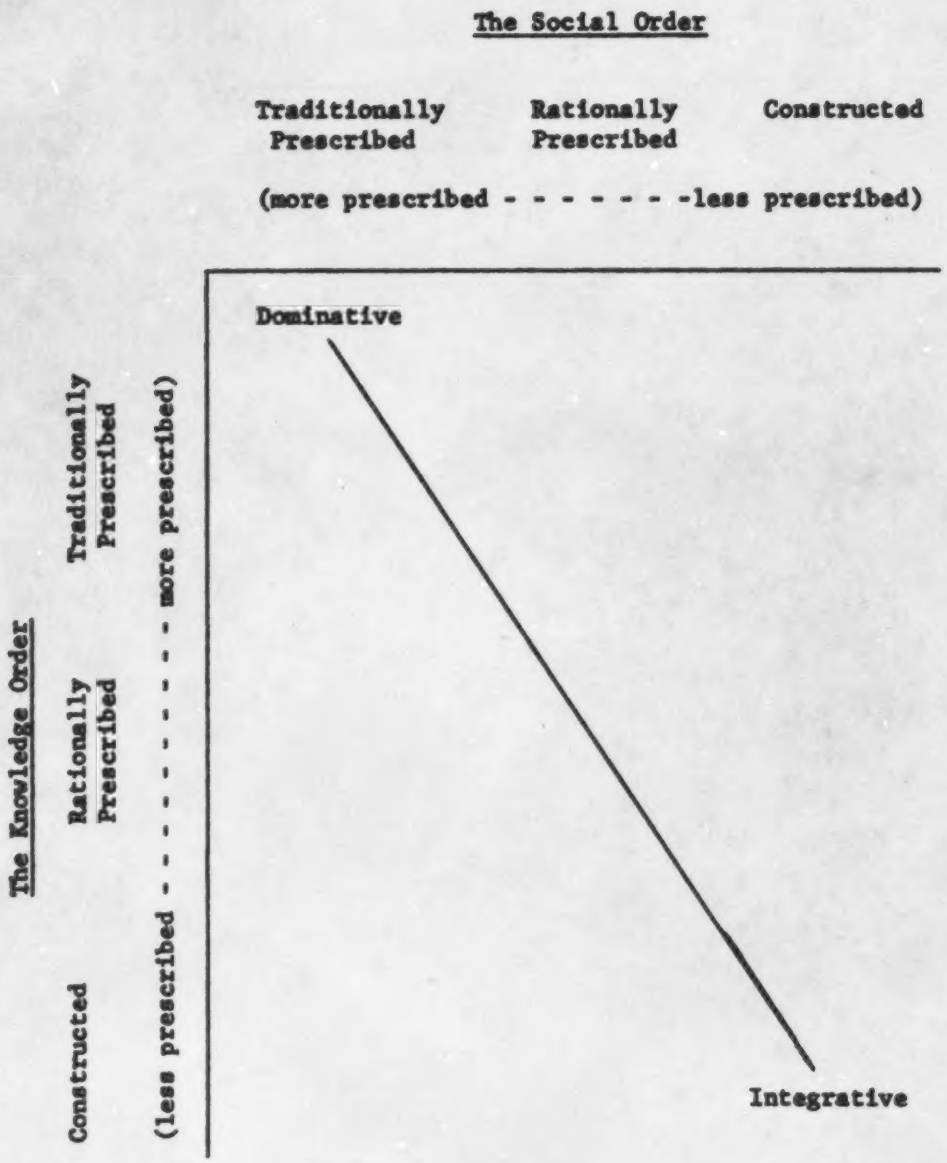
Figure 1. The Knowledge, Social, and Authoritarian Dimensions of Effective Learning Environments.

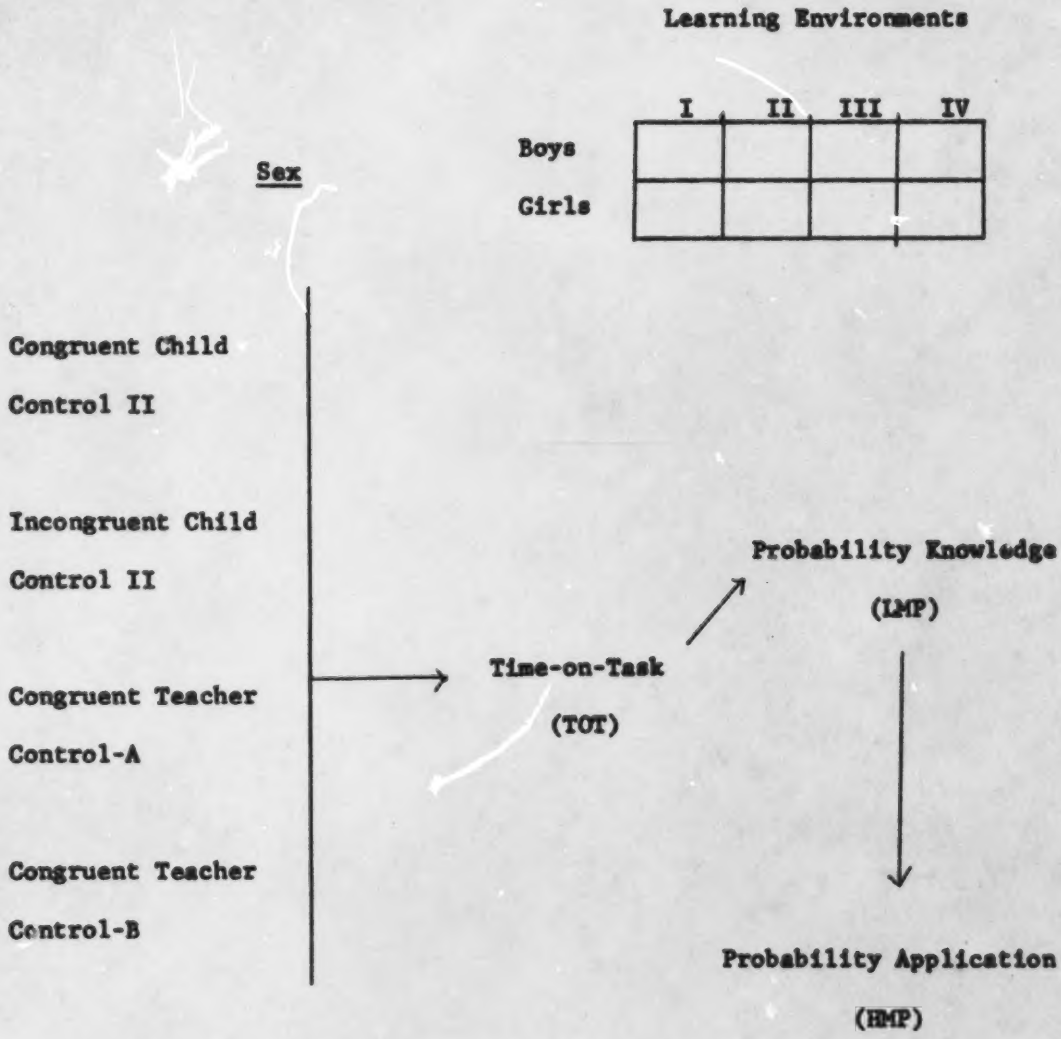
Figure 2. Conceptual Model.

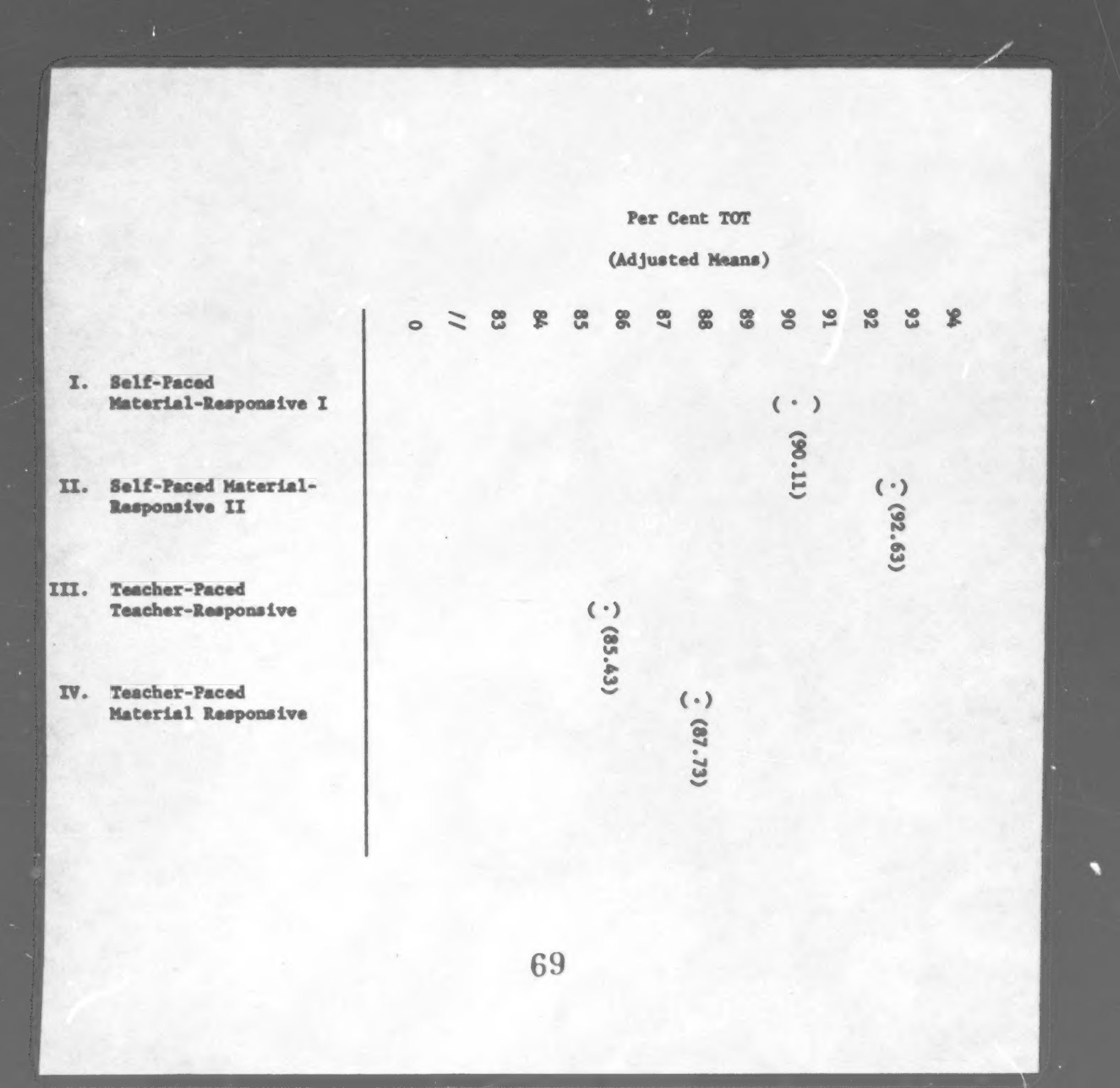
Figure 3. The Relationship Among Learning Environments with Respect to Time-On-Task.

Figure 4. Adjusted Mean LMP Scores for each Learning Environment (including two standard errors).

Figure 5. Adjusted Mean HMP Scores for each Learning Environment (including two standard errors).


The Social Order
Traditionally Prescribed
Rationally Prescribed
Constructed
(more prescribed - - - - - - -less prescribed)
Dominative
Integrative
The Knowledge Order
Traditionally Prescribed
Rationally Prescribed
Constructed
(less prescribed - - - - - - - - - - - - more prescribed)


Learning Environments
I
II
III
IV
Boys
Girls
Sex
Congruent Child
Control II
Incongruent Child
Control II
Congruent Teacher
Control-A
Congruent Teacher
Control-B
Time-on-Task
(TOT)
Probability Knowledge
(LMP)
Probability Application
(HMP)


Per Cent TOT
(Adjusted Means)
0
//
83
84
85
86
87
88
89
90
91
92
93
94
I. Self-Paced Material-Responsive I
II. Self-Paced Material-Responsive II
III. Teacher-Paced Teacher-Responsive
IV. Teacher-Paced Material Responsive
(90.11)
(92.63)
(85.43)
(87.73)

Scores
23
22
21
20
19
18
17
16
15
//
0
(·) (17.66)
(·) (18.94)
(·) (20.60)
(·) (18.78)
Self-Paced Material Responsive I
Self-Paced Material Responsive II
Teacher-Paced Teacher-Responsive
Teacher-Paced Material-Responsive
SE = .38

14
13
12
11
10
9
8
//
0

SE = .34

Self-Paced Material Responsive I (·) (10.20)

Self-Paced Material Responsive II (·) (10.88)

Teacher-Paced Teacher-Responsive (·) (12.77)

Teacher-Paced Material-Responsive (· (12.14)

Appendix A

Means and Standard Deviations for Total Number of Observations Per Individual Per Learning Environment (ALT)

(N = 114)

	Implemented Learning Environments	Mean	Standard Deviation	Inclusive Range
I.	Self-Paced Material-Responsive (N=26)	69.31	11.60	43
II.	Self-Paced Material-Responsive (N=29)	80.30	10.31	34
III.	Teacher-Paced Teacher-Responsive (N=31)	82.83	5.80	29
IV.	Teacher-Paced Material-Responsive(N=28)	82.50	10.20	46